CHAPTER 8

COST ANALYSES OF SCENARIOS OF ALTERNATIVE FUEL USE IN HAWAII'S GROUND TRANSPORTATION SECTOR

8.1 INTRODUCTION

This Chapter estimates the costs associated with alternative fuel use in Hawaii's ground transportation sector. The estimates are based on the vehicle technologies discussed in Chapter 4, the infrastructure requirements discussed in Chapter 6, and land use and fuel production discussed in Chapter 7. Cost estimates are constant dollars.

Cost projections are retail, "at-the-pump" amounts into which all infrastructure, shipping costs, and taxes have been taken into account. Results are shown to the nearest cent because it is handy to use this format when comparing alternative fuel costs to gasoline prices at the pump. The range between the "low" and "high" cost estimates are intended to give an indication of relative uncertainty of the estimates.

Cost estimates for each of the alternative fuels have a different emphasis. For the alcohol fuels, since manufacturers are currently pricing alcohol and comparable gasoline cars at the same level, the most important element becomes the cost of the fuel. Biodiesels are similar to alcohols in that the main cost element is fuel cost. For electric vehicles, both vehicle cost and fuel (electricity) costs are considered; however, emphasis is on the vehicle technology and cost. For propane, both vehicle and fuel costs are considered.

The results of the cost evaluations are useful in considering the following questions:

- Are any of the alternative fuel options which passed the screening analysis currently cost-competitive with gasoline or diesel? If not, to what extent are the alternatives more expensive?
- What are the key cost factors and how can they be reduced?
- If a public subsidy is necessary to support an alternative fuels program, what level of support would be required? (This is discussed further in Chapters 9 and 10, using the results of the cost analyses.)
- Is it possible to structure an alternative fuels program so that the benefits justify the costs? If so, how? (Results of the cost evaluations form the basis for discussion in Chapters 9, 10, and 11.)

Although these questions are addressed in this study *for the current situation,* results will change as costs and technologies change. The estimation tools developed in this project are intended to readily allow this type of re-evaluation.

8.2 ALCOHOLS: METHANOL AND ETHANOL

8.2.1 SCOPE AND ORGANIZATION

The analysis focuses on a limited number of scenarios, outlined below, which are useful in developing policy. Because cars and light trucks fueling at retail stations account for a large percentage of gasoline consumption, the fuel cost projections are for fuels sold through retail stations.[1]

Cost analysis results are in dollars per gasoline equivalent gallon (GEG) at the pump.[2] In this analysis, we make the conservative assumption that the efficiency of alcohol flexible-fuel vehicles (FFVs) is equal to gasoline vehicle efficiency.[3] All production costs for methanol produced from biomass and ethanol produced from sugar cane are taken from Chapter 7.

8.2.2 METHANOL SCENARIOS

Scenario M1a: Methanol Shipped from Canada: Container Shipment

In this scenario, Canadian[4] methanol would be imported in 6100 gallon tanks (Henry, 1993) and trucked directly to the methanol refueling stations. Gasoline would be added to the M85 tank separately. This is the most likely supply scenario for methanol when volumes are fairly low and before local production could commence.[5] A range of importation volumes is considered, from a single container (about 6000 gallons M100) to enough M100 to reduce retail station per gallon costs to an approximately constant and small level (about 170,000 gallons M100).

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1 This could include privately owned and operated vehicles as well as vehicles in commercial fleets which fuel at retail stations. Costs could be different for government fleets or centrally-fueled commercial fleets. Costs will also be different for heavy-duty vehicles in a variety of applications.

2 A "gasoline equivalent gallon" (GEG) is that volume of alcohol which contains as much energy as a gallon of gasoline. For M85 (85 percent methanol, 15 percent gasoline), a gasoline equivalent gallon is about 1.75 gallons. For E85 (85 percent ethanol, 15 percent gasoline), a gasoline equivalent gallon is about 1.4 gallons. Given equal efficiency of converting the fuel to power at the wheels, a vehicle would go as far on a gasoline equivalent gallon of alcohol as it would on a gallon of gasoline.

3 Data shows that current FFVs operating on M85 are slightly more efficient than comparable gasoline vehicles. Gasoline equivalent mileage of current FFVs on M85 is about 3 to 11 percent higher than that of vehicles using industry average gasoline, and 6 to 16 percent higher than that of vehicles operating on California Phase 2 reformulated gasoline (Browning, 1993).

4 The (low and high) price assumed is the range of prices adopted for methanol sold through the California Methanol Reserve. The methanol sold through the reserve comes from Canada and therefore includes all applicable duties and tariffs. California uses Canadian methanol because the American methanol industry does not have the excess capacity to supply the Reserve.

5 HNEI estimates that to achieve reasonable economy of scale, a fiber-to-methanol plant would need to manufacture at least 50 million gallons of methanol per year. As part of this study, HNEI sized the first methanol plant on Oahu at 59 million gallons per year (mgpy) of methanol (see Chapter 7). To provide a range of estimates, however, this study includes costs for fiber-to-methanol plants as small as 10 mgpy. Fiber could be provided by any of a number of feedstocks, from bagasse to dedicated energy crops such as grasses and trees (fiber-to-methanol technology is still under development). HNEI estimates it would take up to 10 years to bring such a plant on-line.

Scenario M1b: Methanol Shipped from Canada: Parcel Tanker Shipment

In this scenario, methanol would be imported in a parcel tanker. This scenario is a variation on the scenario above and would apply at higher import volumes.[6] In the parcel tanker scenario, a terminal would be built at Barbers Point to receive the methanol.[7] Tank trucks are assumed to load gasoline at the Honolulu Harbor terminal and methanol at the Barbers Point terminal and transport M85 (blended in the tank truck) to the stations. Volumes from 714,000 gallons to over 60 million gallons per year (mgpy) of M100 are considered.

Scenario M2a: Methanol Produced on Oahu from Fiber

In this scenario, methanol would be produced on Oahu from fiber.[8] The methanol would be trucked directly from the plant to methanol refueling stations. The plant gate price is assumed to include the cost of enough live storage at the plant to remove the need for an intermediate storage facility, such as a tank farm. The tank trucks are assumed to first take on 15 percent gasoline by volume at the Honolulu Harbor terminal. This assumption is made because it would be safer to haul methanol/gasoline blends than pure methanol, as was described in Chapter 6. Three production volumes are investigated: small volume (10 mgpy), volume large enough to achieve reasonable economy of scale (59 mgpy), and large volume (two 92 mgpy plants). These larger volumes correspond to the plant sizes estimated for Oahu in Chapter 7.

Scenario M2b: Methanol Produced from Coal Gasification on Oahu

In this scenario, methanol would be produced on Oahu from coal. In all other respects, except for tax treatment, this scenario is identical to scenario M2a.

Scenario M3: Methanol Produced from Fiber on a Neighbor Island and Transported by Barge to Oahu

In this scenario, methanol would be produced on a neighbor island, trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The methanol would be received at a terminal at Barbers Point and trucked from the terminal to methanol refueling stations, as in the parcel tanker scenario. Three production volumes are investigated: small volume (10 mgpy), volume large enough to achieve reasonable economy of scale (67 mgpy), and large volume (375 mgpy, produced at three 125 mgpy plants). These larger volumes correspond to the plant sizes estimated for the Big Island in Chapter 7.

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[6] Parcel tanker shipment was originally assumed to become more economical than container shipment at volumes greater than about 840,000 gallons (20,000 barrels or about 140 containers) based on industry estimates (Henry, 1993), and a 20,000 barrel terminal, assumed to be built at Barbers Point to receive the methanol from the parcel tanker, was costed as part of this study. However, further assessment showed that at 20,000 barrels annual throughput, the expense of the terminal exceeds the shipping cost savings associated with bulk shipments. Parcel tanker shipments appear to become more economical for annual volumes of about 1.5 mgpy.

[7] The State of Hawaii's Department of Transportation's Harbor Division would not allow the Honolulu Harbor to receive methanol because the Harbor Division is trying to rid the Honolulu Harbor of hazardous land uses.

[8] This scenario would apply to any island producing alcohol fuel and consuming all of that which is produced. In this study Oahu is used for this scenario since transportation energy consumption on Oahu is much greater than on the other islands.

8.2.3 ETHANOL SCENARIOS

Scenario E1a: Ethanol Shipped from Canada: Container Shipment and Sold as E85

In this scenario, ethanol would be imported via container ships and then hauled by truck (one container per truck) directly to the ethanol refueling stations. Gasoline (15 percent by volume) would be added to the E85 tank either before or just after the ethanol delivery, at the time of a regularly scheduled gasoline drop. This would be a possible supply scenario for ethanol in the early years when volumes are fairly low and before an in-state biomass conversion facility could be built.[9] A range of annual import/consumption volumes is considered, from a single container (about 6000 gallons E100) to enough E100 to reduce retail station per gallon costs to an approximately constant and small level (about 170,000 gallons E100).

Scenario E1b: Ethanol Shipped from Canada: Container Shipment and Sold as E10

In this scenario, ethanol would be imported via container and then hauled by truck (one container per truck) directly to the terminal. A range of annual import/consumption volumes is considered, from a single container (about 6000 gallons E100) to about 170,000 gallons E100. All of the E10 scenarios include an incremental gasoline cost of 2 cents per gallon for refiners to reduce gasoline volatility. Since adding small amounts of ethanol to gasoline results in a higher volatility, controlling the initial gasoline volatility is necessary to insure compliance with American Society for Testing and Materials (ASTM) standards (State DBEDT, 1991).

Scenarios E2a and E4a: Ethanol Produced on Oahu and Sold as E85

In these scenarios, ethanol would be produced on Oahu from waste paper, green waste, and other organic constituents of municipal solid waste (MSW) (scenario E2a) or sugarcane (scenario E4a) and transported by truck from the plant to ethanol refueling stations. The trucks are assumed to take on 15 percent gasoline by volume at the Honolulu Harbor terminal before driving to the ethanol plant to load ethanol. This is identical to scenario M2 except that the fuel would now be ethanol instead of methanol. Costs would be the same for the two scenarios except for tax treatment and plant gate price. Two production volumes, 7 mgpy and 30 mgpy, are shown for each scenario. For ethanol from MSW, these sizes correspond to quantities of waste material (7 mgpy from waste paper; 30 mgpy from total organic fraction of the waste stream) available on a single island (Oahu).

Scenarios E2b and E4b: Ethanol Produced on Oahu and Sold in Gasohol (E10)

In this scenario, ethanol would be produced on Oahu, as described in Scenarios E2a and E4a above, and transported by truck to terminal facilities at the harbor. Ethanol would be blended at 10 percent by volume at the rack and the E10 would be transported to refueling stations by truck.

[9] Ethanol production is less sensitive to economies of scale than plants that manufacture methanol from biomass. HNEI estimates that facilities to produce ethanol could be built as small as about 5 mgpy without poor economy of scale. Production of ethanol from sugars is a proven technology which could be implemented immediately. Independent of the scenario-dependent schedules in which we predict a demand of this magnitude to develop (see Chapter 4), HNEI estimates it would take up to 10 years to bring a (cellulose plus hemicellulose) fiber-to-ethanol plant on-line. Fiber could be provided by any of a number of feedstocks, from municipal solid waste (MSW) to energy crops such as grasses and trees.

Scenario E3a and E5: Ethanol Produced on a Neighbor Island, Transported by Barge to Oahu and Sold as E85

In these scenarios, ethanol would be produced on a neighbor island from molasses (E3a) or sugarcane (E5), trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The ethanol would be received at a terminal at Barbers Point and trucked from the terminal to the ethanol refueling station. This would be identical to scenario M3 except that the fuel would be now ethanol instead of methanol. Costs are the same for the two scenarios except for tax treatment and plant gate price. Two production volumes, 1 mgpy and 3 mgpy, corresponding to maximum availability of molasses on a single island, are used for the molasses scenario. For ethanol from sugarcane, production volumes of 60 and 100 mgpy (two 30 mgpy plants and two 50 mgpy plants) are used.

Scenario E3b: Ethanol Produced on a Neighbor Island, Transported by Barge to Oahu and Sold in Gasohol (E10)

In this scenario, ethanol would be produced on a neighbor island from molasses (E3b), trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The ethanol would be received at a terminal at Barbers Point and transported by truck to terminal facilities. Ethanol would be blended at 10 percent by volume at the rack and the E10 would be transported to refueling stations by truck.

8.2.4 RESULTS OF THE ALCOHOL SCENARIOS

8.2.4.1 PROJECTED ALCOHOL FUEL COST AT THE PUMP FOR VARIOUS SCENARIOS

Results for the methanol scenarios are shown in Table 8-1. Projected methanol (M85) costs at the pump, in gasoline equivalent gallons (GEG), range from a high of $6.06 to a low of $1.79, depending on the supply scenario and the volume of annual demand. The highest prices are seen in the containerized import scenario (M1) at very small volumes, and the lowest in the scenario of production from fiber and use on the same island (no inter-island barge transport) (M2a) with the highest volume.

The column showing prices "With GEG-adjusted Taxes" shows projected costs if state and county fuel taxes were adjusted on the basis of energy content. This would be a reasonable, fuel-neutral adjustment and would not involve any subsidies, tax incentives, or redirection of funds (and the alternative fuels still pay their "fair share" of highway taxes). This is discussed further in Chapter 9. Projected costs at the pump with this adjustment range from a high of $5.79 to a low of $1.52, depending on scenario and volume.

Results for the ethanol scenarios are shown in Table 8-2. Projected low-level ethanol blend (E10) costs at the pump range from a high of $1.77, with the highest costs seen in the containerized import scenario, to a low of $1.52 in the scenario of production from MSW and use on Oahu (E1b).

Table 8-1
Results of Methanol Cost Analyses

Methanol Scenarios	Methanol Annual Volumes (gallons 100% alcohol)	**Sold as M85**			
		With Existing Taxes		With GEG-adjusted Taxes (2)	
		Low Pump Price ($/GEG) (1)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)
M1a. Methanol Imported	6,000	$2.86	$6.06	$2.59	$5.79
- Containers	170,000	$2.87	$3.59	$2.60	$3.32
M1b. Methanol Imported	714,000	$3.61	$4.50	$3.34	$4.23
- Parcel Tanker	1,275,000	$2.93	$3.52	$2.66	$3.25
	>60,000,000	$2.09	$2.35	$1.82	$2.08
M2a. Methanol Made from Banagrass on Oahu	10,000,000	$2.23	$3.57	$1.96	$3.30
	59,000,000	$1.86	$3.09	$1.59	$2.82
	184,000,000	$1.79	$2.92	$1.52	$2.65
M2b. Methanol Made from Coal	1,247,000	$2.89	$2.90	$2.62	$2.63
with electricity co-production	1,247,000	$2.27	$2.28	$2.00	$2.01
M3. Methanol Made from Banagrass	10,000,000	$2.72	$4.16	$2.45	$3.89
on a Neighbor Island and Shipped to Oahu	67,000,000	$2.13	$3.35	$1.86	$3.08
	375,000,000	$2.02	$3.13	$1.75	$2.86

Notes:
1. $/GEG refers to $ per gasoline equivalent gallon. One gasoline equivalent gallon = 1.4 gallons of E85, 1.74 gallons of M85, and 1.03 gallons of E10.
2. Since alternative fuels contain less energy per gallon, more gallons are used to travel the same distance. GEG-adjusted taxes would take this into account.

Table 8-2
Results of Ethanol Cost Analyses

Ethanol Scenarios	Ethanol Annual Volumes (gallons 100% alcohol)	**Sold as E10**		**Sold as E85**			
				With Existing Taxes		With GEG-adjusted Taxes (2)	
		Low Pump Price ($/GEG)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)
E1a&b. Ethanol Imported - Containers	6,000	$1.71	$1.77	$3.48	$5.85	$3.32	$5.69
	170,000 +	$1.68	$1.71	$3.49	$3.95	$3.33	$3.79
E2a&b. Ethanol Made from Waste on Oahu	7,000,000	$1.53	$1.65	$1.72	$3.53	$1.56	$3.37
	30,000,000	$1.52	$1.63	$1.59	$3.30	$1.43	$3.14
E3a&b. Ethanol Made from Molasses on a Neighbor Island and Shipped to Oahu	1,001,075	$1.67	$1.73	$3.43	$4.41	$3.27	$4.25
	3,003,225	$1.58	$1.61	$2.42	$3.07	$2.26	$2.91
E4a&b. Ethanol Made from Sugarcane on Oahu	7,000,000	$1.56	$1.70	$2.08	$4.13	$1.92	$3.97
	30,000,000	$1.55	$1.68	$1.94	$3.91	$1.78	$3.75
E5. Ethanol Made from Sugarcane on a Neighbor Island and Shipped to Oahu	60,000,000	not calculated see note (1)	not calculated see note (1)	$2.28	$4.14	$2.12	$3.98
	100,000,000			$2.28	$4.04	$2.12	$3.88

Notes:
1. Total statewide gasoline demand is less than 400 million gallons per year; ten percent would be less than 40 million gallons.
2. Since alternative fuels contain less energy per gallon, more gallons are used to travel the same distance.GEG-adjusted taxes would take this into account.

Projected high-level ethanol blend (E85) costs at the pump range from a high of $5.85 per gasoline equivalent gallon, with the highest costs seen in the containerized import scenario (E1) at very small volumes, to a low of $1.59 in the scenario of production from MSW and use on Oahu (E2a). With adjustment of taxes on the basis of energy content, high-level ethanol blend costs at the pump range from a high of $5.69 to a low of $1.43 per gasoline equivalent gallon.

Figures 8-1, 8-2, and 8-3 display information from Tables 8-1 and 8-2, as well as an average price for regular unleaded gasoline in Honolulu (DBEDT, 1993), in graphic form.

It is readily apparent (See Figures 8-1 and 8-2) that high level alcohol blends (M85 and E85) are more costly than gasoline on a GEG basis. Lower-level alcohol blend (E10) scenarios (see Figure 8-3) have projected costs which are much closer to current gasoline prices.

Figure 8-1
M85 Scenarios: Projected Costs

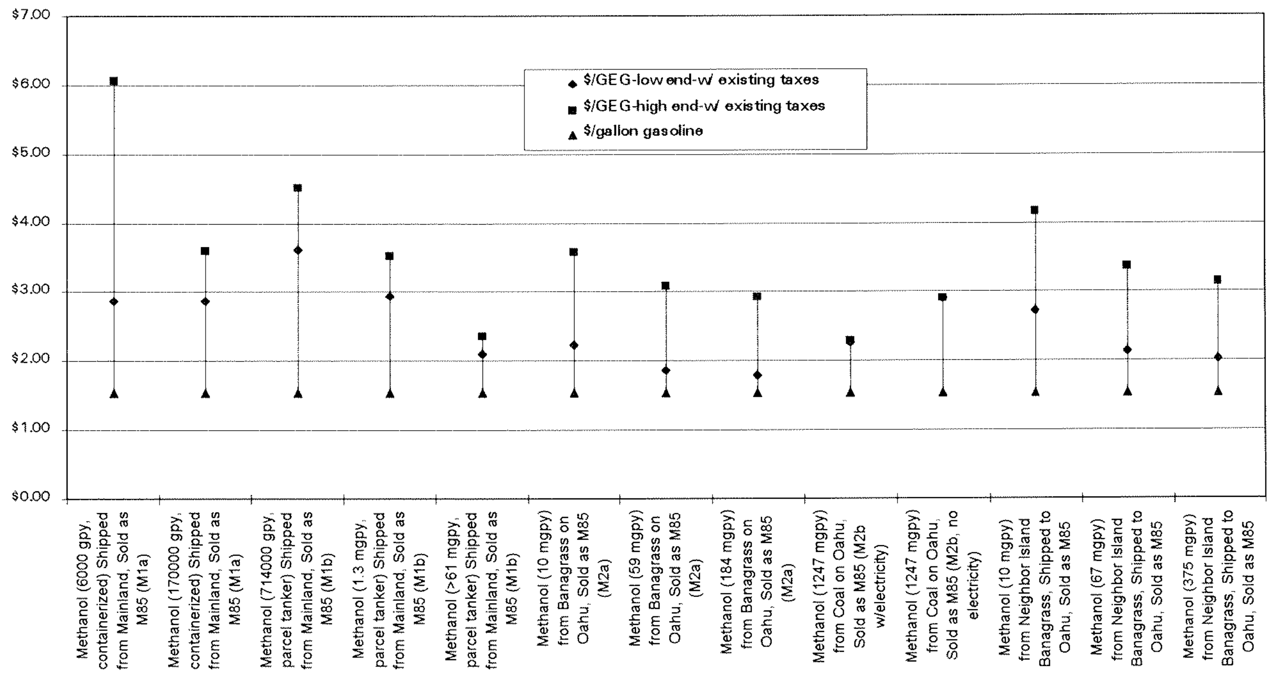


Figure 8-2
E85 Scenarios: Projected Costs

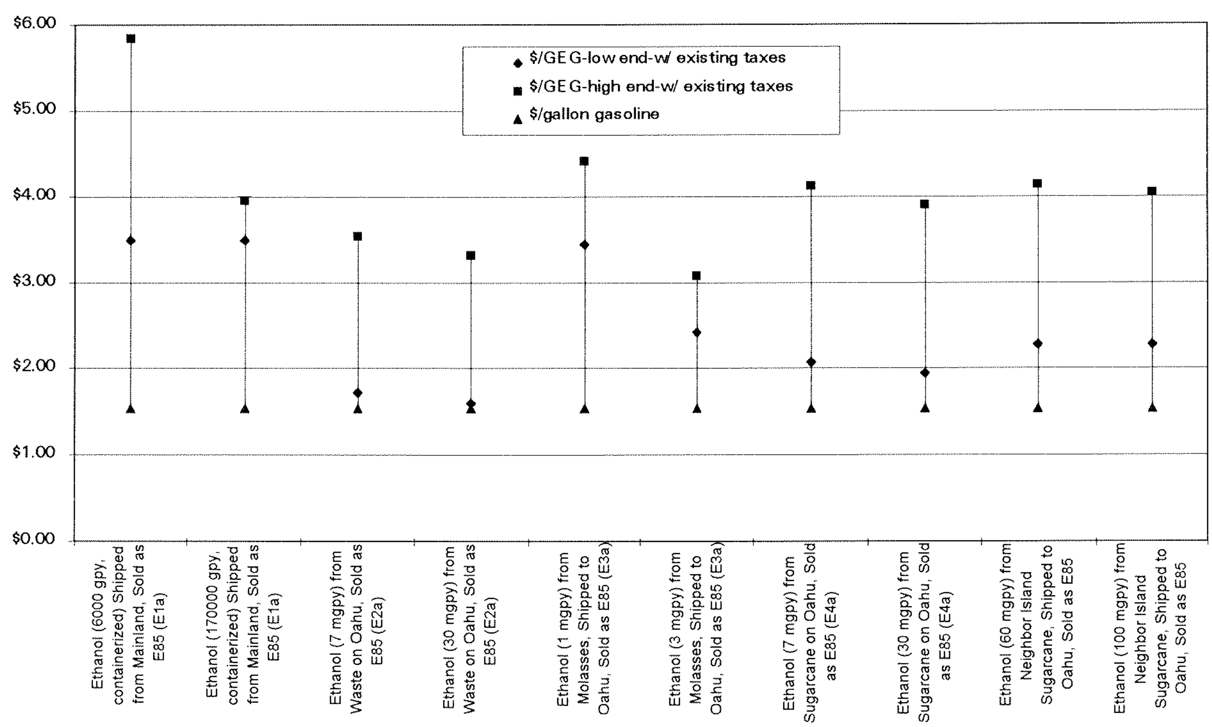
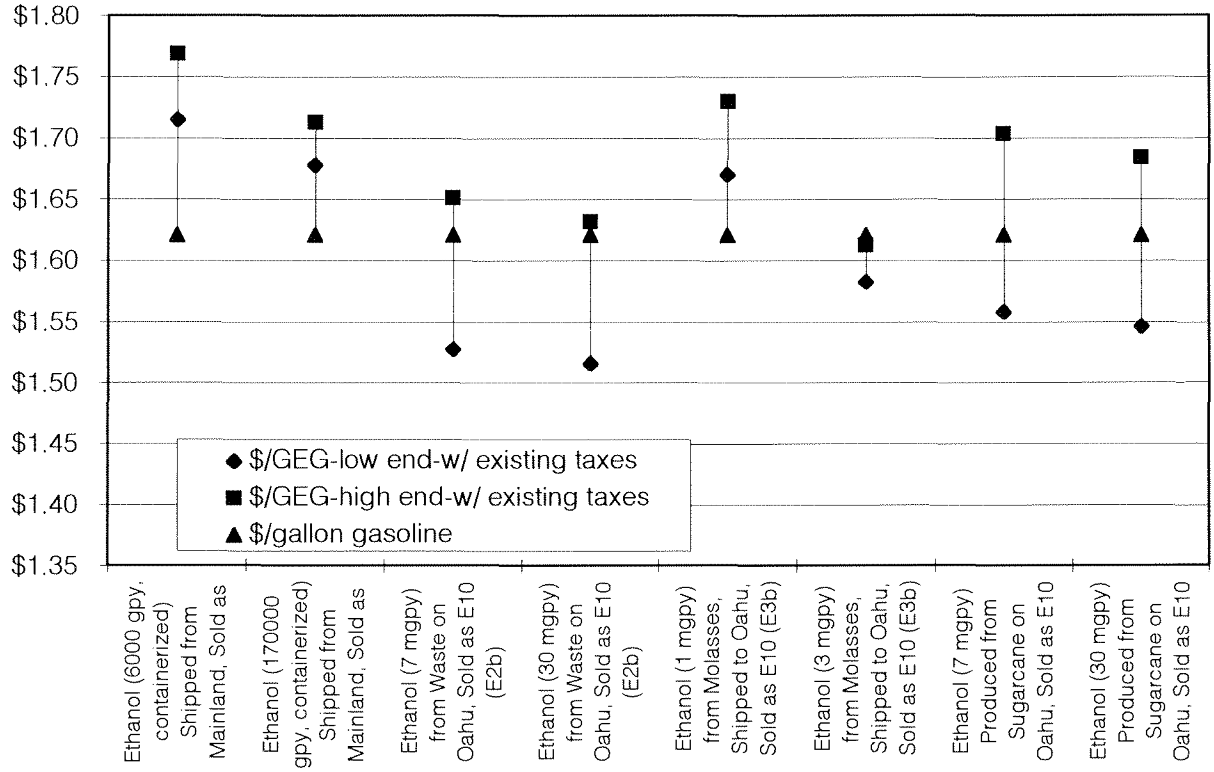


Figure 8-3
E10 Scenarios: Projected Costs



The lowest cost alcohol fuel scenario is the low cost case of ethanol from waste on Oahu. It is important to note that the spread between the low cost case and the high cost case of this scenario is quite wide, indicating that several major cost items are uncertain. In this case, key high cost elements are newly-developed (and as yet uncommercialized) processing technology and federal alcohol fuel tax credits. Cost components' influence on scenario results are discussed in the next section. The amount of ethanol from this feedstock (and therefore the amount of ethanol at this price) is limited to the quantity of waste material available.

Figure 8-4 shows the maximum alcohol production possible from the various feedstocks. Production is given in percent of transportation energy consumed in the ground sector statewide in 1990 (see Chapter 2). Based purely on the acreage of good agricultural land on which energy crops might be grown (disregarding the costs and vehicle compatibility requirements of such an endeavor), enough ethanol or methanol could be produced from locally-grown materials to supply all of the ground sector transportation energy in the state.

Figure 8-5 superimposes projected costs for the high-level methanol (M85) and ethanol (E85) blend scenarios on Figure 8-4 to show pump price ranges as well as the maximum available alcohol for various scenarios. Pump price, shown on the right axis, is in dollars per GEG at the pump for 85 percent alcohol blends. Volume, shown on the left axis, is in percent of 1990 transportation energy in the ground sector. Evaluation of alternative fuel scenarios, or

Figure 8-4

Energy Potentially Available from Alcohol Fuels in Hawaii

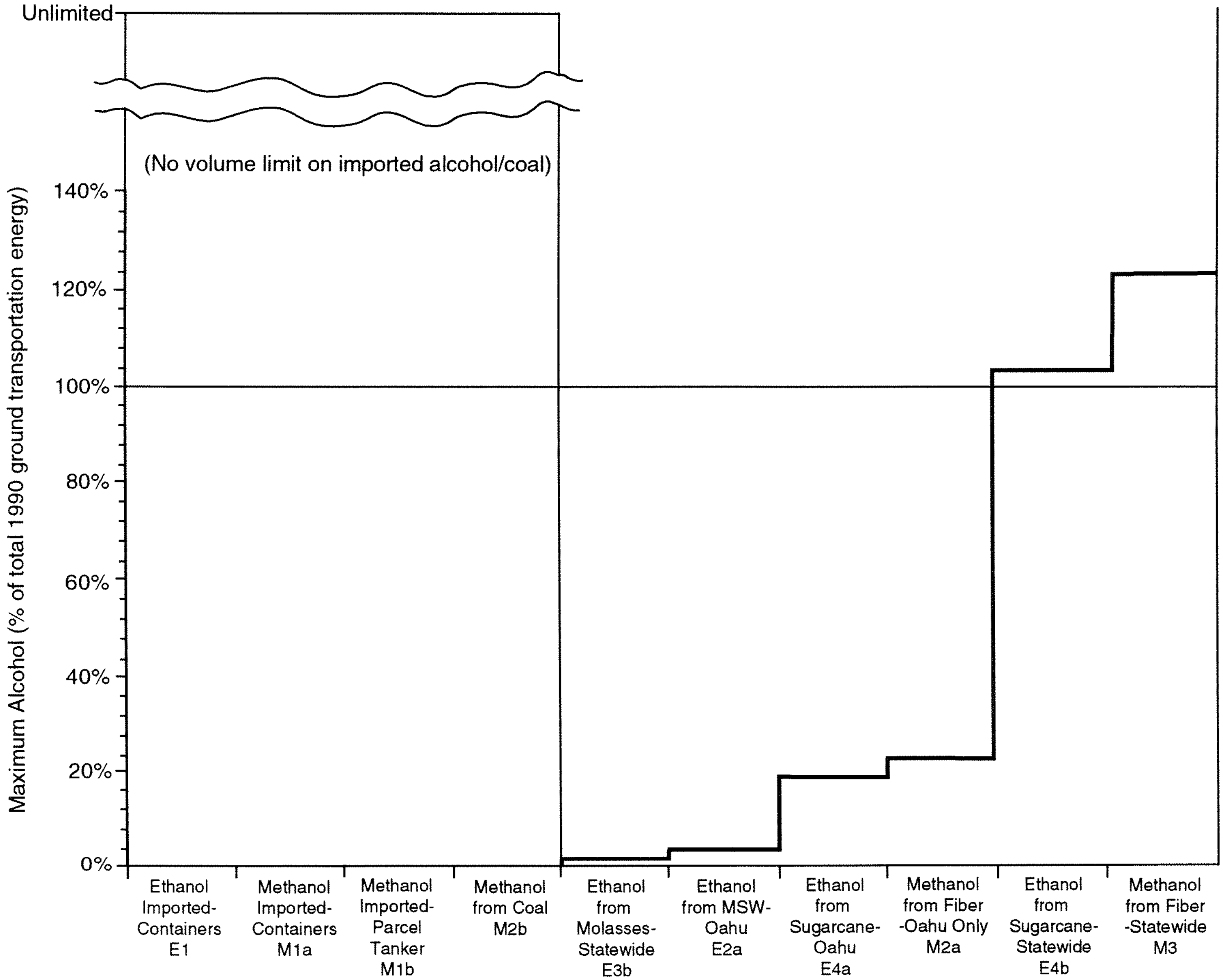
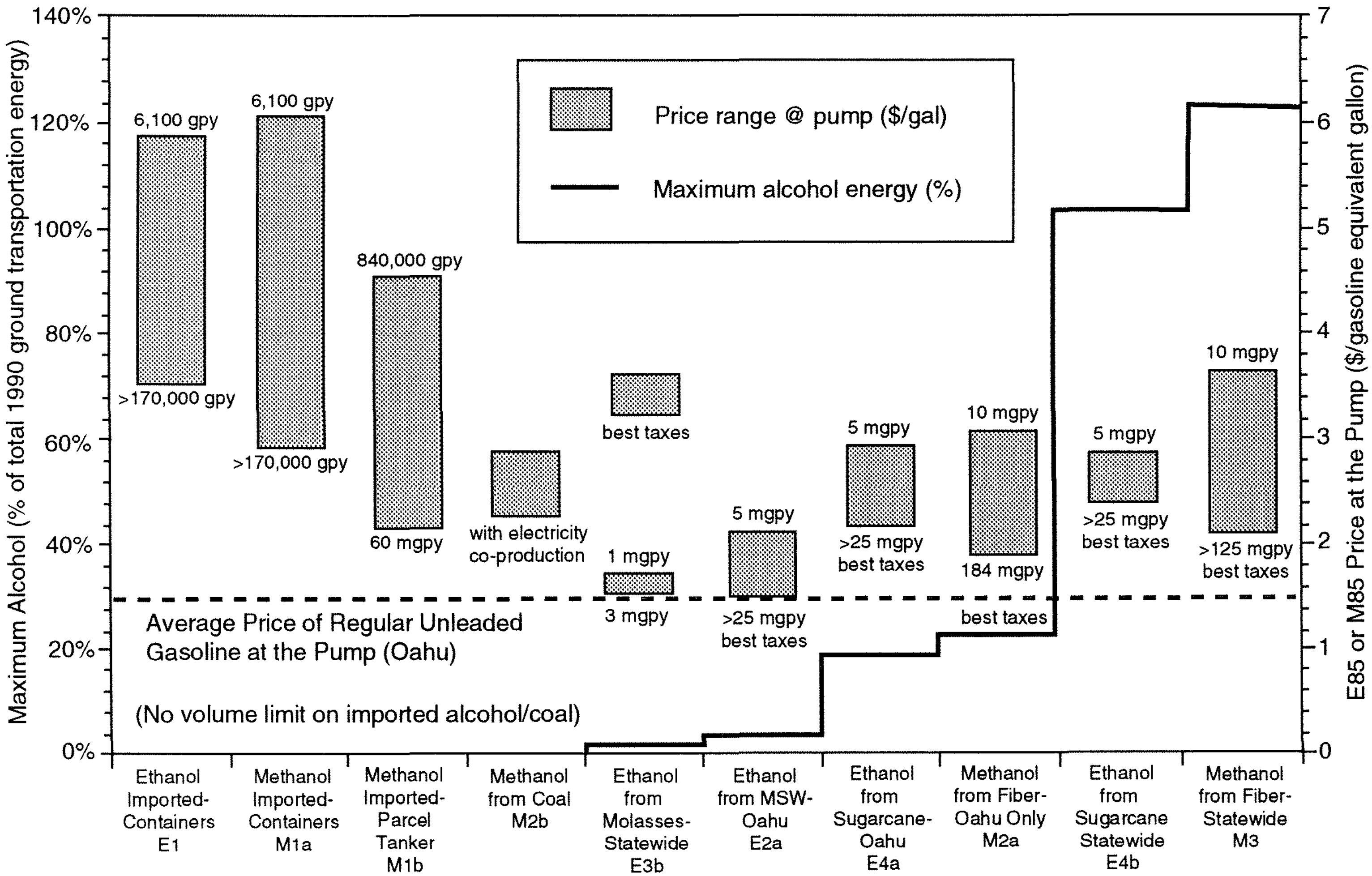


Figure 8-5

Energy Available and Gasoline Equivalent Pump Price Range of M85 and E85 Fuels in Hawaii

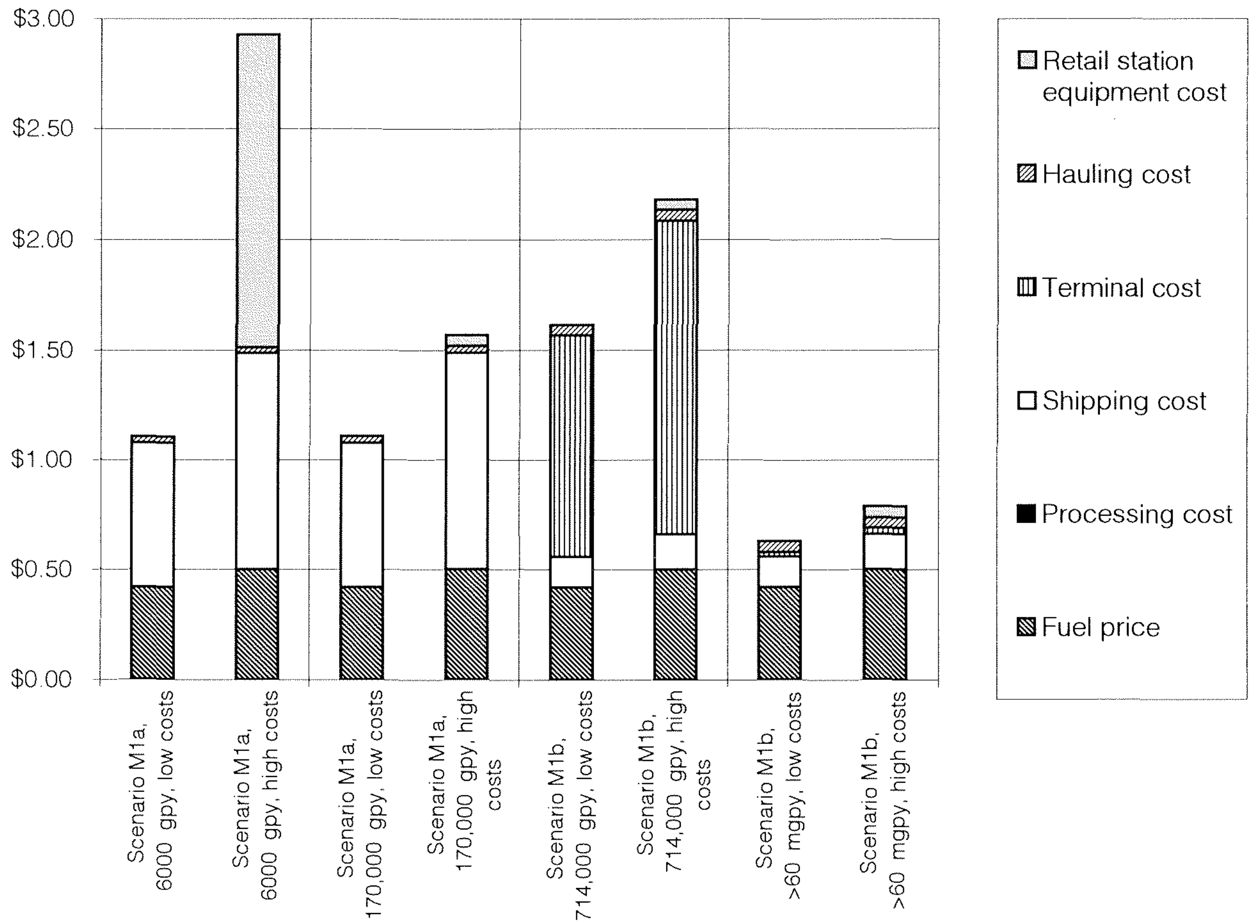


combination of scenarios, must consider both cost and availability at different levels of demand.

8.2.4.1 IDENTIFICATION OF KEY COST ELEMENTS AND UNCERTAINTIES

The cost analyses allow identification of key cost components and uncertainties. Although site-specific analyses are beyond the scope of this study, the analysis tools developed may be used for preliminary estimates of fuel costs for specific sites and conditions. Also, as key cost elements change, the impact of these changes on the bottom line may be evaluated. Selected "high cost" and "low cost" scenarios, shown in Figures 8-6 and 8-7, illustrate this type of comparison.

Figure 8-6
Examples of Key Cost Components And Uncertainties For Selected Methanol Import Scenarios



In a container import scenario (see Scenario M1a in Figure 8-6), the high cost case is quite high at very low import volumes, but decreases with increasing sales volume up to about 200,000 gpy. As may be seen by comparing the second and fourth bars in the graph, this is because, per gallon of alcohol sold, the capital costs associated with offering alcohol fuel at a retail station (installing alcohol tanks and dispensers, for example) decreases as the volume of alcohol sold increases (the low cost cases, represented by the first and third column in Figure 8-6, assume that existing tanks are used; therefore, there are no new facility installation costs). At about 200,000 gpy throughput, the retail margin falls to 4 cents per gallon, and therefore the pump price of alcohol could only fall by a few more cents per GEG if the throughput increased. At this volume, it is assumed that it would be more worthwhile to increase the number of stations offering alcohol than to further increase a single station's throughput. This is the only scenario in which the total annual demand volume is assumed to be in a low enough range that retail station costs vary with the annual demand volume. In all other scenarios, the number of stations is chosen such that annual throughput roughly equals 200,000 gallons, subject to a maximum number of stations of 300, about the number of retail stations on Oahu (Zane, 1992).

In the parcel tanker scenario (see Scenario M1b in Figure 8-6), the lower per gallon cost of shipping methanol in bulk rather than in 6100 gallon tanks is offset by the added cost of constructing a terminal to receive bulk shipments. At low annual demand volumes (i.e. the 714,000 gpy scenario) this added cost is very high. As the throughput volume increases, the terminal costs per gallon fall to one to a few cents per gallon. The lowest cost case (over 60 mgpy) results in greatly reduced terminal costs.

The impact of terminal cost is also apparent in scenarios which involve production of alcohol fuel on one island and shipment between islands (see scenario M3 in Figure 8-7).

The projected costs of biomass-derived alcohols are primarily influenced by feedstock price, processing cost, plant scale, and, in scenarios which include barging between islands, shipping and terminal-related costs. Whether the plant is assumed to be able to take full advantage of the alcohol fuel tax credit, shown as part of the "processing cost," has a very large effect on the final pump price. The low cost cases include low processing costs in addition to full use of the tax credit; the high cost cases include high actual processing costs and do not take advantage of the tax credit. The magnitude of individual cost elements may be seen in the cost tables in Appendix A-3.

Fuel taxes are another important element in projected fuel costs at the pump. Under current state and County fuel tax laws, motor fuels are taxed on a per-gallon basis. This puts most alternative fuels at a disadvantage on a cost-per-mile basis, since alternative fuel vehicles use more gallons to travel the same distance. The effect of this on the projected methanol costs is shown in Figure 8-8.

Figure 8-7
Examples of Key Cost Components And Uncertainties For Selected Methanol Production Scenarios

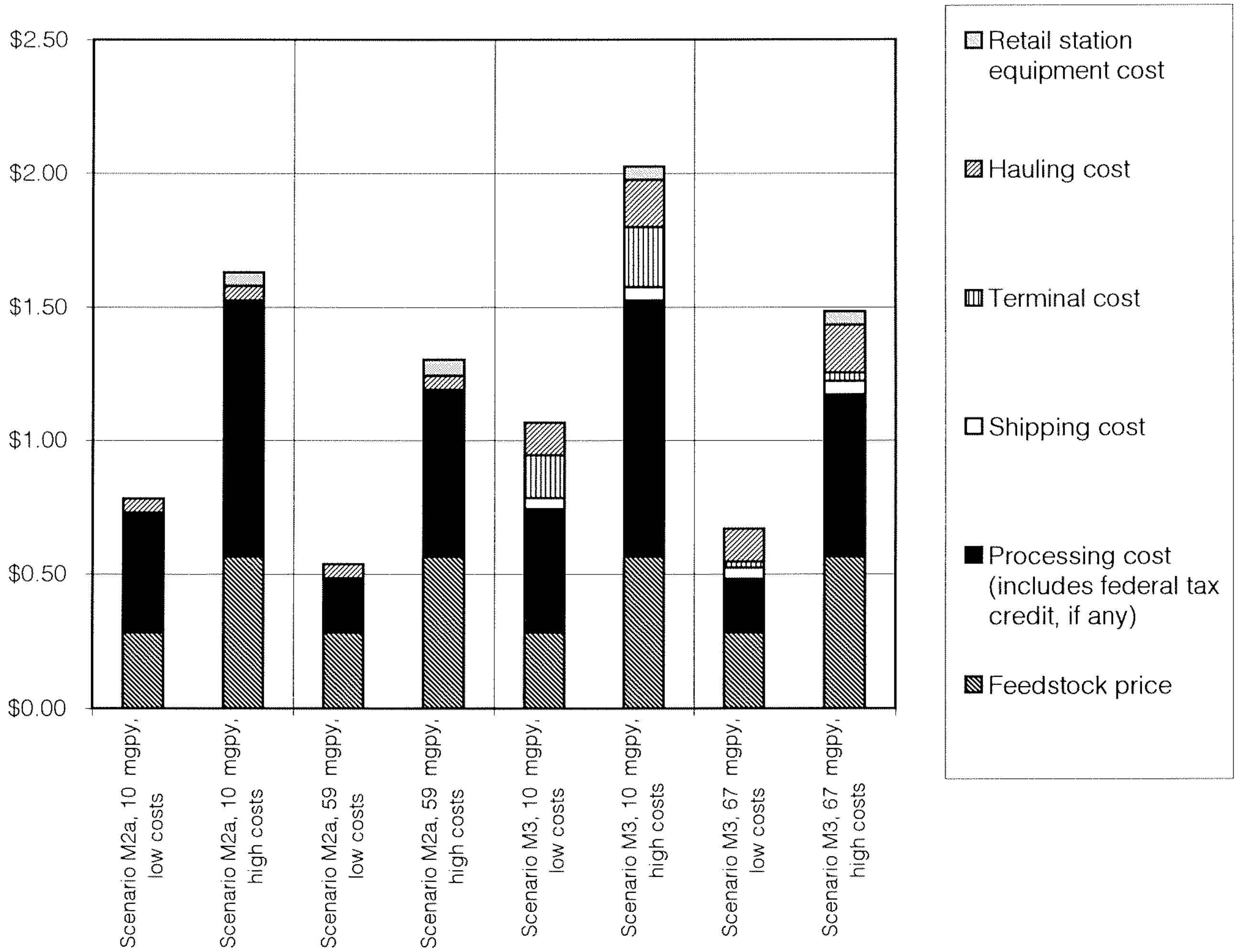
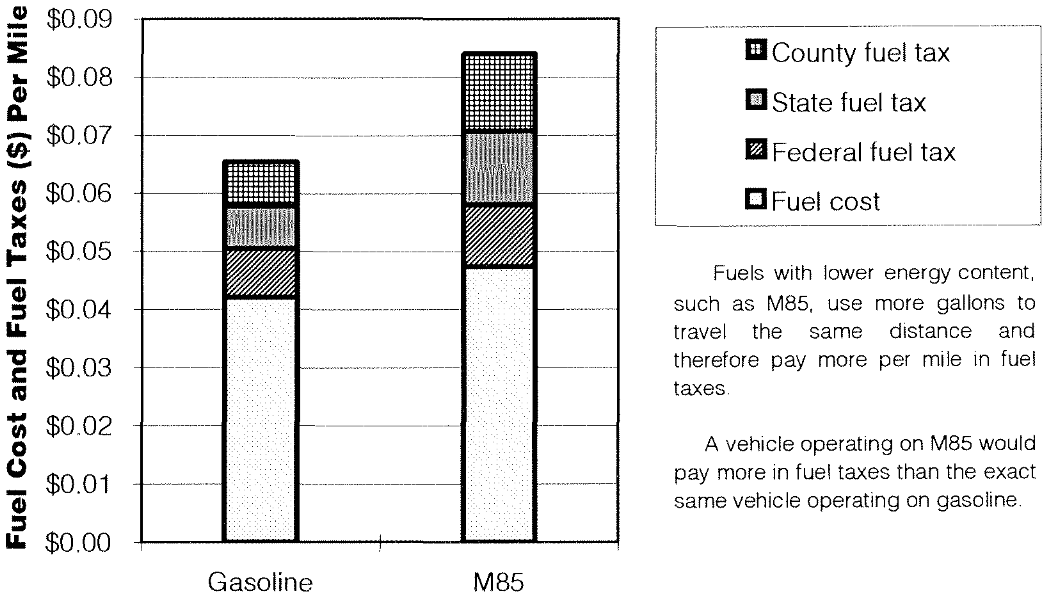


Figure 8-8
Fuel Taxes are Higher for M85 Than for Gasoline



Fuels with lower energy content, such as M85, use more gallons to travel the same distance and therefore pay more per mile in fuel taxes.

A vehicle operating on M85 would pay more in fuel taxes than the exact same vehicle operating on gasoline.

As cost elements change (for example, changes in tax laws, improved biomass yields resulting in reduced feedstock costs, availability of lower-cost feedstocks and/or by-products of other agricultural crops, increased alcohol yields, reduced equipment and processing costs, or even reduced financing costs), or as specific information allows assumptions to be fine-tuned (for example, current assumptions contain logistics of tank truck drivers spending 4 to 7 hours per round-trip to Hilo Harbor and quite a bit of back-and-forth from Honolulu Harbor to Barbers Point), the impact of those changes may immediately be evaluated simply by changing the appropriate values in the cost estimation model.

8.2.5 COMPETITIVENESS OF IMPORTED ALCOHOLS

8.2.5.1 METHANOL

Mainland methanol is derived from natural gas and thus costs considerably less at the point of production than is projected for biomass-derived methanol produced in Hawaii. Methanol imported in bulk has the potential to be competitive with methanol produced in Hawaii, depending on the local production scenario (see Figure 8-1). However, if methanol produced in Hawaii were to be subsidized at the point of production by the state to be competitive with gasoline at the pump, imported methanol would not be able to compete.

The conclusion that imported methanol would not be competitive with methanol produced locally in Hawaii from biomass is valid only for the scenario considered. Another possibility might apply during a mature program in Hawaii with a fairly high demand for alcohol fuel. If methanol prices in the American continents were in a period of weakness, and higher shipping volumes to meet Hawaii demand could allow dedicated tanker shipments, it is conceivable that imported methanol could approach the prices of methanol produced locally. This possibility deserves some attention in the detailed design of any incentive program.

How likely is it that imported methanol could compete with local methanol receiving incentives? Figure 8-9 shows the history of spot methanol prices in the Texas Gulf (in 1987 constant dollars). There have been several recent periods during which methanol was available at prices in the neighborhood of 30 cents per gallon. In 1972, methanol was at less than 20 cents for a brief period. These low prices would appear to correspond to variable production costs (including cost of feedstock, operating and maintenance, and shipping), at least based on recent cost analyses.[10] In these periods, producers evidently were willing to sell at variable costs for a period of time to avoid costs of mothballing plants and laying off employees, and perhaps to meet commitments to purchase feedstock gas.

If another "methanol bust" episode of this type occurred in the future, it is possible that producers of methanol from natural gas might attempt to sell into a Hawaii market. However, this appears extremely unlikely. Additional shipping costs to Hawaii, even in moderate-sized tanker ships (as compared with parcel tankers) bringing methanol from Canada, Central America, South America, or South East Asia or even from more distant locations, combined with a 20 or 30 cent methanol price, would result in a landed methanol price in Hawaii of about 40 cents per gallon of M100, which would be $0.28 per gallon less than the projected cost for methanol produced from large-scale fiber-to-methanol plants in Hawaii.

Although there is always some risk of competition for a large market, it does not appear likely that methanol produced from natural gas would compete in Hawaii with gasoline or with locally-produced methanol that received local incentives sufficient to make it competitive with gasoline.

8.2.5.2 ETHANOL

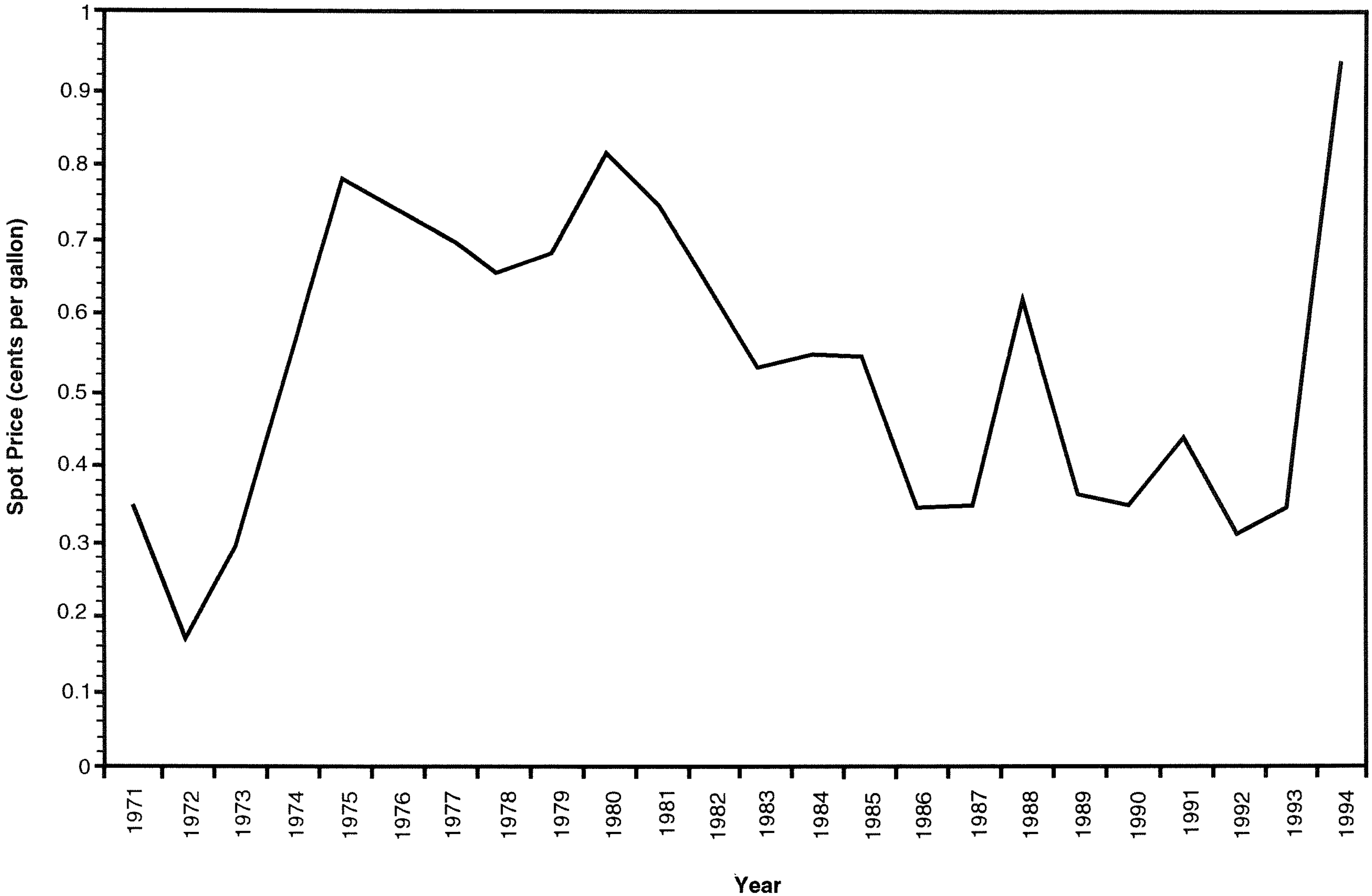
While production costs vary with the cost of labor, plant scale, market price, revenues from by-products, and other factors, the cost of ethanol produced in Hawaii from low-cost biomass feedstocks is projected to be similar to ethanol produced from corn on the mainland. Since mainland ethanol is mostly produced in the midwest, the cost of transport by truck or rail to the west coast of the U.S. or Canada[11] would be added to the costs of overseas shipment to Hawaii. Thus, ethanol shipped from the mainland would be disadvantaged compared to locally-produced ethanol as both trucking and shipping costs would be added to the relatively similar production costs. Fortunately, an ethanol program need not depend on imports in the early years (as a methanol program would) because relatively efficient small scale ethanol plants in the 1 to 5 million gpy range could be brought on-line relatively quickly.

[10] See for example, Bechtel, Inc., San Francisco, California, California Fuel Methanol Cost Study, Final Report, Vol. II (Managing Sponsor: Chevron USA, San Francisco, California), December, 1988, and Acurex Corporation, Mountain View, California, Methanol as a Motor Fuel: Review of the Issues Related to Air Quality, Demand, Supply, Cost, Consumer Acceptance and Health and Safety, California Energy Commission, Sacramento, California, P500-89-002, April, 1989.

[11] If the ethanol was shipped from a U.S. Port, The Jones Act would require shipping under U.S. flag, which could be even more expensive.

Figure 8-9

History of Methanol Average Annual Spot Price in the U.S. Gulf



8.2.6 CONCLUSIONS OF THE ALCOHOL COST ANALYSES

M85 and E85

Considering all cases of alcohol in 85 percent blends (M85 or E85), only ethanol (E85) produced locally from MSW, under favorable conditions (i.e. the "low pump price" case), could be viewed as competitive with current gasoline prices at the pump.[12] If adjustments were to be made to fuel taxes on the basis of energy content, methanol (M85) from banagrass is also projected, under favorable conditions, to be competitive with current gasoline prices at the pump. In all other scenarios, 85 percent alcohol blends are more costly at the pump than even premium gasoline (about $1.73 per gallon).

Changes in a number of factors may affect costs. The impact of such changes may be calculated using the analysis tools developed in this project; scenarios may be run for a variety of assumptions. Policies which affect any of the cost elements may be tested for each of the scenarios.

E10

Due to E10's higher octane level than regular unleaded, it may be most appropriate to compare E10 prices to premium (or mid-grade) gasoline where, in fact, it appears that E10 could compete at the pump.[13] As with M85 and E85, cost projections are sensitive to changes in any number of assumptions and cost factors; the impact of such changes may readily be calculated using tools developed in this project.

8.3 BIODIESELS

The possible feedstocks for local production of biodiesels and the cost implications of each were discussed in Chapter 5. The most cost-effective option was production of biodiesel fuel from waste oil from, for example, restaurants. A representative of Interchem Industries, Inc. estimates that waste oil could be converted into biodiesel fuel at a price of about $1.50 per gallon of finished product (Ayers, 1993). If used in diesel vehicles at a twenty percent blend (80 percent petroleum-based diesel), this would add a cost of about 15 cents per gallon to the price of diesel fuel.[14] As described in Chapter 5, waste oil is estimated to be able to provide only 500,000 to 700,000 gallons per year (Ayers, 1993). This is less than 1 percent of the total diesel fuel currently consumed in the ground sector.

[12] It may be expected that, if alcohol fuels were to actually compete with gasoline on the basis of price, gasoline pump prices would decrease in response to the new competition.

[13] About 42 percent (or 160 million gallons) of the gasoline sold in Hawaii in 1992 was mid-grade or premium (Energy Information Administration, 1992). If E10 were to replace this volume of mid-grade and premium gasoline sales, this would provide a market for about 16 million gallons of ethanol per year. If E10 were to replace all sales of gasoline, the Statewide market for ethanol would be about 38 mgpy.

[14] This estimate assumes a diesel rack price of 73 cents per gallon based on 1993 data and no fuel economy change due to use of the biodiesel blend.

Tropical oil crops grown in Hawaii include macadamia nuts and kukui nuts. Oils from these crops currently sell into high-price markets such as the cosmetic industry. The wholesale price for macadamia nut oil is about 15 to 18 dollars per gallon (Hawaii Kukui Nut Company, 1993),[15] kukui nut oil is even more costly. Considering that this is over ten times the typical price of soybean oil, it seems clear that these crops are not logical candidates for biodiesel feedstock. Information allowing an analysis of locally-produced biodiesel using the Chinese tallow tree, a potentially promising high-yield crop (discussed in Chapter 5) is not readily available (Boom, 1993).

Other potential feedstocks include soybeans, peanuts, or sunflowers. If these crops were to be grown in Hawaii at sufficient scale, biodiesel could be manufactured in Hawaii and the biodiesel price would be similar to the mainland price of $2.50 per gallon (Ayers, 1993). This price would result in an incremental price increase of about 35 cent per gallon of twenty percent biodiesel.

8.4 ELECTRIC POWERED VEHICLES

The phrase "electric vehicle technology" encompasses a very wide range of vehicle design (see Chapter 4). Furthermore, electric vehicle technology is developing at a rapid rate; a great deal of research is underway to optimize battery technology and fuel cell technology to maximize performance and bring costs down to an acceptable level. Research on other components of electric vehicle drive systems is ongoing as well. Research efforts extend to vehicle bodies: unconventional carbon fiber bodies are being considered as a lightweight alternative to traditional automotive materials to extend electric vehicle range.

Because electric vehicle development encompasses so many technologies, most of which may not mature for a number of years, and because, further, the most commercially-auspicious technologies have not yet become apparent, providing typical costings for electric vehicle operation is difficult. Most of the cost data currently available from electric vehicle demonstrations is not representative of even near-future electric vehicle technology. For example, the majority of the available data is for the limited-production Vehma-Conceptor G-Van (at a very high vehicle sales price of $55,000 to $60,000 per van) which is out of production and which Vehma-Conceptor and Electric Power Research Institute (EPRI) do not plan to reintroduce. Furthermore, field data varies widely with the vehicle and the application. For all of these reasons, it is very difficult, if not impossible, to construct representative costings of electric vehicle use in Hawaii upon which it would be appropriate to base energy strategy recommendations. Such data is expected to come out of the Hawaii Electric Vehicle Demonstration Program (HEVDP) (see Chapter 4). Therefore, the electric vehicle costs estimated in this study should be viewed as very preliminary. This study provides brief discussions of some of the main elements of battery-electric vehicle life-cycle costs and purchase prices for a number of currently available models.

[15] For contracts for more than 11,000 pounds, prices may be lower and are individually negotiated.

The cost of operating a battery-electric vehicle involves several elements. Key cost-related elements include:

- initial vehicle purchase;
- battery replacement;
- maintenance/parts;
- electricity/recharging; and
- federal, state, and local incentives.

8.4.1 INITIAL VEHICLE PURCHASE

Electric vehicle (EV) prices span a very wide range. Some of the EVs recently or currently available are very expensive. For example, the Vehma-Conceptor G-Van as mentioned above was sold for $55,000 to $60,000, and the currently available Chrysler electric version of the Dodge Caravan/Plymouth Voyager is available for approximately $100,000. Another very recent example comes from Santa Clara County, California, which agreed in March of 1994 to acquire 8 modified electric Geo Prizms for about $41,500 each (San Francisco Chronicle, 1994). Relatively inexpensive EVs are available as well, typically from small-volume manufacturers. For example, the Suntera Sunray, manufactured in Hawaii, is projected to be priced at $12,000.

The major automobile manufacturers are readying their EV technologies to meet the California requirement that 2 percent of the vehicles offered for sale in the state beginning in 1998 be zero-emission vehicles. The big three have been cooperating in order to meet this requirement, forming industry consortia to further electric vehicle technology. Regardless of the large amount of effort being focused on developing commercial electric vehicles, the major manufacturers still anticipate that electric vehicles will be much more costly to produce in the early years than conventionally fueled vehicles. Ford anticipates that the electric vehicles offered initially in 1998 will present Ford with a $10,000 loss per electric vehicle sold if the vehicles are priced to be competitive in the marketplace (Nichols, 1993). Ford does anticipate, based on prior experience introducing new technologies, that this initial high cost will "wear off" over the next ten years so that in the 2008 timeframe, electric vehicles would be competitively priced and the manufacturer would not take a loss on the sale of the vehicle (Nichols, 1993). Table 8-3 lists purchase price information as available for a number of currently available EV models.

Table 8-3
Electric Vehicle Purchase Prices for Selected Models

Manufacturer	Model	Description	OEM*	Range (miles) @30 mph	Price
B.A.T. Technology	Geo Metro	Small auto	N	80	$15,900
B.A.T. Technology	Ford Ranger	Small truck	N	80	$24,100
California Alternative Propulsion Company	Selectable Drive Hybrid	Small truck	N	70	$20,000
California Electric Cars, Inc.	Big Sur	Jeep	N	120	$21,900
California Electric Cars, Inc.	Monterey	Small auto	N	150	$35,000
Chrysler	Minivan	Minivan	Y		$100,000
Domino Cars, U.S.A.	Minilight	Small auto	N	93	$21,000
Eco-motion	Ion-1	Small auto	N	80	$15,995
Elcat	Elcat Cityvan	Minivan	N	65	$20,000
Green Motorworks, Inc.	Kewet El-jet	Small auto	N	40	$13,000
Green Motorworks, Inc.	Speedster	Small auto	N	60	$32,000
Herb Adams, V.S.E.	Jackrabbit	Small auto	N	110	$24,000
Sebring Auto-Cycle, Inc.	ZEV-Colt	Small auto	N	60	$24,000
Solectria	Force (PbAcid)	Small auto	N	90	$26,000
Solectria	Electric Pick-up	Small auto	N	80	$40,000
Solectria	Force (NiCad)	Small auto	N	130	$60,000
Specialty Vehicle Manufacturing Corp.	Model 3122	Trolley	Y	50-75	$140,000
Specialty Vehicle Manufacturing Corp.	Model 4122	Shuttle	Y	50-75	$109,000
Specialty Vehicle Manufacturing Corp.	Model 5122	Shuttle	Y	50-75	$130,000
Specialty Vehicle Manufacturing Corp.	Model 5122	Bus	Y	50-75	$140,000
Suntera	Sunray	Small auto	Y	87	$12,000
US Electricar	Geo Prizm	Small auto	N	NR	$41,500
VoltAge, Inc.	Voltzvogon	Small auto	N	45	$11,500

*Vehicles manufactured by Original Equipment Manufacturers (OEMs) versus conversion/retrofit technologies marked "Y".

8.4.2 BATTERY REPLACEMENT COSTS

Battery costs are significant in the overall cost of operating an EV. For example, the lead-acid battery pack for the limited-production G-Van must be replaced every 30,000 miles at a cost of $7,000 to $8,000 (McCoy and Lyons, 1993b). General Motors estimated that batteries for the Impact will cost about $1,500 to replace every 20,000 to 25,000 miles (McCoy and Lyons, 1993b). Considering battery cost as a component of fuel cost for the moment, this is a substantial price to pay. To draw a simple comparison, a recent model year car with an assumed fuel economy of 30 miles per gallon would consume about 830 gallons of fuel to travel 25,000 miles. If gasoline cost $1.50 per gallon, the cost of fuel for 25,000 miles of travel in a conventional car would be about $1,250. For the Impact, 25,000 miles of travel would cost $1,500 for the batteries alone, on top of the cost of purchasing electricity to recharge the batteries.

One useful way to look at battery costs is in terms of dollars per kilowatt-hour (kWh). A kilowatt-hour, like British thermal unit (Btu), is a unit of energy. The kWh supplied by a battery pack is related to the vehicle range: as the kWh capacity per charge increases, so does the vehicle range. For example, an EV with a 15 kWh battery pack and an energy economy of 0.25 kWh per mile would have a range of 15/0.25 = 60 miles between recharges. Table 8-4 shows projected costs of various battery technologies as well as the cost criterion adopted by the U.S. Advanced Battery Consortium in cost per kWh (The Lewis Center for Regional Policy Studies, 1993).

Table 8-4
Projected Battery Costs

Battery Type	Projected Cost ($/kWh)
Lead-Acid	70-100
Nickel Iron	160-300
Nickel Cadmium	300
Sodium Sulfur	100+
Lithium Iron Sulfide	100-200
Zinc Bromide	100-300
Nickel Metal Hydride	200
USABC Mid-Term Criterion	150
USABC Long-Term Criterion	100

Source: The Lewis Center, 1993.

EV battery technology is the focus of a great deal of research and development. In addition to the relatively mature lead-acid technology, several battery technologies are being examined for use in EVs, including sodium-sulfur, nickel-iron, and nickel cadmium. Research into recharging methods is underway, as well, and significant advances are being made. Recently the world record for miles traveled by an EV in a 24-hour period was shattered due to a new charging technique allowing 16 kWh of charging in less than 19 minutes. Such speed will increase the consumer appeal of EVs, but more importantly for cost reduction, the charging technique is also much easier on the battery. The new technique, which involves a computer-controlled charging algorithm developed by Electronic Power Technology, Inc., is expected to result in a much longer battery life (San Jose Mercury News, 1994). Continued improvements in battery and recharging technology should result in substantial cost savings in the future.

8.4.3 ELECTRICITY COSTS

The cost of electric power to recharge EVs is another key factor in evaluating the cost of operating an EV. By way of example, the Hawaiian Electric Company (HECO) general service (Schedule "G") rate is 10.5763 cents per kWh (Waller, 1993). For the G-Van, with an average energy consumption of 1.44 kWh/mile (Waller, 1993), this rate would result in a per mile electricity cost of about 15 cents per mile. This is relatively high; for a gasoline van achieving 15 miles per gallon, a 15 cent per mile fuel cost would imply a gasoline price of about $2.30 per gallon. However, EV development is resulting in increasingly efficient vehicles. Greater efficiency brings electricity costs per mile well below gasoline prices. For example, a small, efficient EV might consume 0.25 kWh per mile. At the Schedule "G" rate, this would result in a per mile electricity cost of 2.6 cents per mile, equivalent to gasoline at $0.79 per gallon for a 30 mile-per-gallon car. Furthermore, the Schedule "G" rate is not necessarily the rate that would apply for EV charging. HECO is currently developing special EV rates (Waller, 1993). Given HECO's interest in meeting minimum load requirements, it might be conjectured that the rate would be designed to encourage EV use, at least for off-peak charging.

As was discussed in Chapter 4, in order for EV use to improve Hawaii's energy security, electric power would need to be generated from non-petroleum sources such as coal, biomass, wind, geothermal energy, and solar energy. In Chapter 7, the production of electricity from biomass is discussed and cost estimates are derived for feedstock at $50 per ton. Electricity costs out of the plant in cents per kWh range from 8 cents per kWh for large plant to 12.5 cents per kWh for a small plant. Furthermore, the National Energy Policy Act of 1992 (EPACT) includes a tax credit for renewable electricity production (limited to wind and closed-loop biomass) of 1.5 cents (in 1992 dollars) per kWh. An assessment of all the renewable energy resources will be important for evaluating the costs and benefits for Hawaii of a program promoting widespread electric vehicle use; such an effort is ongoing in Project 3 of the Hawaii Energy Strategy.

Finally, the cost of recharging infrastructure will not be large in many cases, depending on type of station. The California Energy Commission (CEC) estimates that installing a typical recharging site will cost about $300 (CEC, 1991). Amortizing such a low cost will not appreciably affect the price of electricity delivered to a vehicle.

8.4.4 MAINTENANCE COSTS

More data will be needed to properly evaluate EV maintenance costs. Furthermore, experience with the introduction of new technologies shows that maintenance costs will drop as the technology matures. In 1991 the Arizona Public Service Company (APSC) collected data on maintenance and labor costs for 11 electric vehicles that the APSC was operating. Table 8-5 shows these costs for electric vehicles compared with counterpart gasoline vehicles also operated by the Arizona Public Service Company (McCoy and Lyons, 1993b).

The Hawaii Electric Vehicle Demonstration Project will produce valuable data on electric vehicle maintenance for a wide range of electric vehicle types. The demonstration program will establish a conversion, service, and maintenance center in Honolulu's Kaka'ako District. This center will provide personnel training as well as vehicle service.

8.4.5 LIFE CYCLE COSTS

Table 8-6 shows examples of life cycle cost analyses for electric vehicles. The best information is that the range of estimates of the cost of operating an electric vehicle is as wide as the range of EV technology currently available. Furthermore, electric vehicle cost analyses are hampered by immature technologies and lack of data. Life cycle cost analyses does not take into account financial incentives for electric vehicles which are a part of EPACT. These incentives are described elsewhere in this report and include a tax credit equal to 10 percent of the costs of purchasing an electric vehicle up to $4,000, and a tax deduction for electric vehicle refueling property up to $100,000 per refueling site.

Table 8-5
Fleet Vehicle Maintenance and Labor Costs at Arizona Public Service Company

Vehicle Type	Maintenance and Labor Cost[1] $/Mile	
	Electric	Gasoline
Electric Escort Sedan	.199	N/A[2]
Electric G-Van	.286	N/A
Electric, all sedans	.205	N/A
Gasoline compact sedan	N/A	.171
Gasoline, full-size sedans	N/A	.471
Gasoline full-size van	N/A	.314

Source: Arizona Public Service Company.
Notes:
1) Labor cost at $23/hour.
2) Vehicle type not applicable to energy source.

8.5 PROPANE

Propane, or liquefied petroleum gas (LPG), has been used in the transportation sector for many years, and the technology is quite mature compared with the other alternative fuels. Key cost elements include vehicle costs (conversion or original equipment manufacturer), fuel costs, and fueling infrastructure costs.

Vehicle Purchase or Conversion Costs

Typically, the LPG vehicle population has consisted of gasoline vehicles converted or "retrofit" to run on LPG. Conversion costs are generally in the range of $1,000 to $2,000 (McCoy and Lyons, 1993a). The Clean Air Center of GasCo has provided parts and services for LPG conversions for over twenty years. Table 8-7 demonstrates the breakdown of projected LPG conversion costs (for conversions performed by GasCo, Inc.) of $2,050 for mid-sized cars, and $1,865 for trucks (State of Hawaii, Department of Business Economic Development & Tourism, 1991; Saito, 1994).

Few LPG vehicles are available from original equipment manufacturers. Ford Motor Company offers an LPG option on its F-series trucks. This option costs approximately $800 more than the equivalent gasoline model. Caterpillar is developing a gaseous fuel powered 3306 engine which can run on LPG or CNG for heavy duty applications. Cost information is not yet available for this engine.

Table 8-6
Examples of Life-Cycle Cost Analyses Results for Electric Vehicles

Vehicle Type	Application	Battery Technology Type	Time Frame	EV Life-Cycle Cost (cents/mile unless otherwise noted)	Comparable Gasoline Vehicle Cost	Notes
Passenger Van	Private Individual	generic	1995	61.7	37.5 -38.2	1,2,3,4,5
Passenger Van	Small Private Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Passenger Van	Large Private Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Passenger Van	Government Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Full-Size Van	Small Private Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Full-Size Van	Large Private Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Full-Size Van	Government Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Source: CEC, 1991						
Passenger Car	None noted	Hybrid: lead-acid battery + 30 hp engine	near term	20.6	not given	5,6,7
Source: Marr and Walsh, 1986						
DSEP Van	None noted	lead-acid	near term	64 or 42	not given	8,9
Source: Marr and Walsh, 1987						
IDSEP Van	None noted	range of technologies	1995	15 to 30	not given	10,11,12,13
G-Van	None noted		1995	30 to 37	not given	11,12,13
Source: Marr et al, 1989						
Shuttle Bus (22')	Commercial	lead-acid	1993	$2.53/mi	$2.19/mi	1,14,15
Shuttle Bus (22')	Commercial	lead-acid	1993	$4.18/passenger	$3.37/passenger	1,14,15,16
Source: AEC analysis based on SVMC cost data, personal communication, Ken Allison, 1993						
Delivery Truck	Commercial	lead-acid	1992	27 to 30	29 to 31	17, 18, 19
Source: Browning, April 1993						

Notes:
1. 10,000 annual miles assumed.
2. 1990 dollars
3. Battery replacement costs not included (analysis assumes vehicle is resold with old batteried after 5 years).
4. Batteries assumed to meet USABC Advanced Battery Technology Criteria, with 5 year life and cost of $6000.
5. Base vehicle costs (excluding sales tax, licensing fees, etc.) assumed to be $26,899 for the passenger van and $24,986 for the full-size van, including batteries.
6. Battery life of 6.4 years and cost of $711 assumed.
7. Vehicle cost of $9867 assumed.
8. State-of-the-art lead-acid batteries assumed. Off-the-shelf configuration gave 64 cents/mi, same batteries with design parameters modified to give minimum life-cycle cost resulted in 42 cents/mi cost.
9. DSEP is Dual-Shaft Electric Propulsion van being developed by Eaton under DOE funding.
10. IDSEP is the Improved Dual-Shaft Electric Propulsion van
11. Annual driving distance assumed to be equal to range of vehicle on a single charge: maximum range per charge varied with battery type (i.e. each technology associated with a different cost and range).
12. Battery technologies analyzed include ZN/Br2, LiA1/FeS, Na/S (max range), Ni/Fe, Fe/Air, and Tubular (min range). Highest costs were with Tubular, lowest with Na/S and Fe/Air.
13. Vehicle capital cost assumptions not noted. Prototype G-Vans were sold for about $55,000 to $60,000.
14. Costing includes vehicle costs, fuel costs and battery costs.
15. Life of electric shuttle assumed 50% longer than gasoline shuttle 10 year life based on DOE estimates.
16. SVMC calculates that the EV shuttles in operation attract more passengers than the gasoline shuttles, at a ratio of about 1.4:1. This results in lower per passenger cots
17. Gasoline truck gross vehicle weight assumed to be 10,500 pounds.
18. Gasoline truck price of $35,000 and EV price of $43,000 assumed.
19. Assumed electricity cost of 8 cent per kWh. Assumed gasoline cost of $1.36 per gallon (California Phase II).

General Notes: A. None of the above results take EPACT incentives into account.

Table 8-7
Conversion Costs for LPG Vehicles

Item	Parts Cost ($)	Labor (Hrs)
Parts (kit)	748.00	16 hours (car or van)
Tank	500.00	12 hours (truck)
Remote fill (not required for some vehicles)	150.00	
Fuel control processor	288.00	

Propane and Infrastructure Cost

GasCo provides propane for motor vehicle use at a separate rate schedule than propane for other uses such as heating and cooking. For vehicle use, propane is essentially priced to be competitive with gasoline after all appropriate motor fuel taxes have been applied. For example, in 1993, on Oahu, fleets paid from $1.00 to $1.33 per gallon depending on their annual consumption volume[16] (Saito, 1994). This translates to a price of $1.36 to $1.82 per gasoline equivalent gallon. Fueling infrastructure is supplied by GasCo (Saito, 1994). Currently, there are about 45 LPG refueling sites supplied by GasCo throughout the islands as well as a few sites supplied by Oahu Gas Service and Aloha LP Gas (Kepoo, 1994). Availability of competitively-priced LPG in Hawaii (for fleet use) reduces the incremental cost of LPG vehicles over conventionally fueled vehicles to the costs associated with vehicle procurement or conversion.

Retail propane, primarily sold for use in barbecue grills and for industrial uses, has a retail price (without highway taxes) of about $2.00 per gallon (telephone survey, 1994), which translates into a cost of $3.36 per gasoline equivalent gallon if all taxes are applied.

Fuel Taxes on Propane

Unlike other alternative fuels, propane is taxed at a rate which is roughly proportional to its energy content ("two-thirds the rate for diesel, rounded to the nearest cent"[17]).

8.6 EXAMPLE OF A COST PER MILE COMPARATIVE ANALYSIS

Table 8-8 shows example assessments of cost per mile for a gasoline, alcohol, electric, and propane-powered passenger car. The gasoline analysis was based on the Intellichoice cost

[16] The price of $1.00 per gallon assumes at least 400,000 gallons per year used; the price of $1.33 per gallon applies down to 800 gallons used per year (Saito, 1994).
[17] Hawaii Revised Statutes, Section 243.

information for a 1994 Ford Taurus GL (Intellichoice, 1994). Figure 8-10 shows the assessment results graphically.

Two alcohol cases were examined: a low fuel cost case and a high fuel cost case, as shown in Table 8-8. Except for EVs, fuel costs, in these analysis, are fuel costs at the pump and therefore include the cost of related fueling infrastructure. EV infrastructure was instead included as a capital item (estimated on a per vehicle basis) rather than as a component of fuel price. Alcohol and propane fuel prices are given per gasoline equivalent gallon (GEG). Propane prices are based on prices for fleet vehicles using a central fueling location.

It is important to note that this analysis is merely a set of examples (other assumptions could give substantially different results) and cannot support general conclusions about the relative cost-competitiveness of these technologies. However, this analysis can illustrate a few interesting points. First, EVs, under these assumptions, are more costly on a per-mile basis than either gasoline, propane, or alcohol vehicles operating on reasonably competitively priced fuel; however, EVoperating costs are much lower than gasoline, alcohol, or propane vehicle operating costs (and would be even if the EV infrastructure cost were loaded onto the fuel price). Therefore, if EV vehicle and battery costs could be reduced, EVs could become very competitive in the marketplace.[18]

Table 8-8
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Common Parameters (Assumptions)		
Miles per Year	10,000	
Discount Rate	10%	
Years of ownership	5	
Resale value	45%	of initial cost

Notes: 1) Assume insurance, fees, and vehicle-related taxes are the same regardless of fuel/energy type; these costs are not included in the comparison.
2) Resale value after 5 years based on Intellichoice* fifth year resale value for a 1994 model year Ford Taurus GL.

Fuel Costs (taxes included)		
Gasoline	$1.52	per gallon
M85 or E85, Low Fuel Cost	$1.43	per GEG*
M85 or E85, High Fuel Cost	$3.81	per GEG
Electricity	$0.105763	per kWh
LPG	$1.96	per GEG

* GEG, "gasoline equivalent gallon," refers to the volume of any fuel which contains the same amount of energy as a gallon of gasoline.

[18] The issue of vehicle range is not addressed in this cost comparison. The implicit assumption is that the user's needs are met by the range of whichever technology vehicle is purchased and that no additional cost are incurred as a result of reduced range compared with a gasoline vehicle.

Table 8-8 (continued)
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Gasoline		
Cost Category	Cost (1994$)	
Vehicle cost	$16,380	
Resale value	$7,371	
Annualized cost	$3,003	
Vehicle cost per mile	$0.30	
Average fuel economy	21.8	mpg
Fuel cost per year	$699	
Maintenance per year	$1,044	
Repair per year	$130	
Annual operating cost	$1,873	
Operating cost per mile	$0.19	
Total Cost per Mile	**$0.49**	

Alcohol (M85 or E85)		
Cost Category	Low Fuel Cost $1.43 per GEG	High Fuel Cost $3.81 per GEG
Vehicle cost	$16,380	$16,380
Resale value	$7,371	$7,371
Annualized cost	$3,003	$3,003
Vehicle cost per mile	$0.30	$0.30
Average fuel economy (miles per GEG)	21.80	21.80
Fuel cost/year	$656	$1,747
Maintenance per year	$1,068	$1,068
Repair per year	$130	$130
Annual operating cost	$1,854	$2,945
Operating cost per mile	$0.19	$0.29
Total Cost per Mile	**$0.49**	**$0.59**

Table 8-8 (continued)
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Electric			
Cost Category	Cost (1994$)		
Vehicle cost	$21,380		
Vehicle cost w/EPACT tax credit	$19,242		
Resale value	$9,621		
Annualized cost of vehicle	$3,207		
Infrastructure cost per EV	$1,000		
Annualized infrastructure	$65		
Battery replacement cost	$2,000		
Annualized battery cost	$1,333		
Total annualized costs	$4,605		
Vehicle cost per mile		$0.46	
Average fuel economy (kWh per mile)			0.30
Fuel cost/year	$317		
Maintenance per year	$522		
Repair per year	$130		
Annual operating cost	$969		
Operating cost per mile		$0.10	
Total Cost per Mile		**$0.56**	

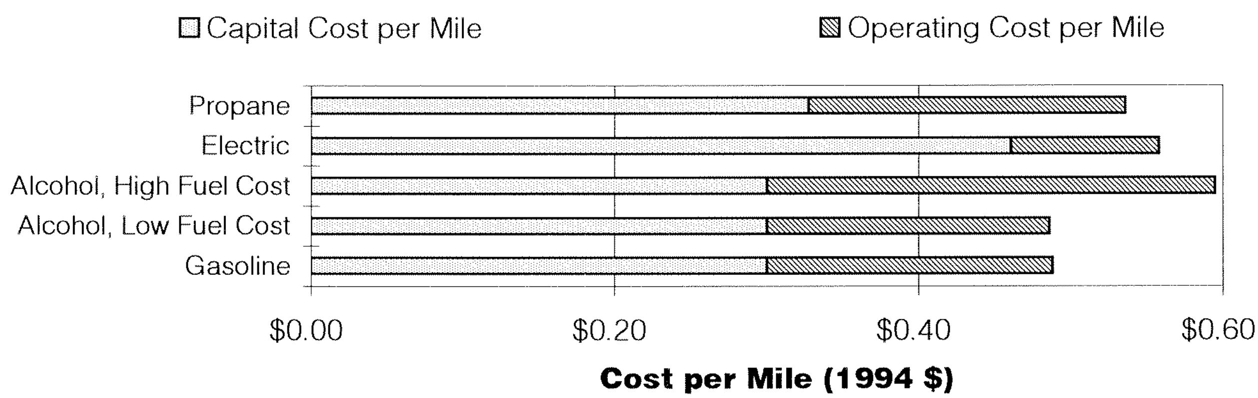
Propane			
Cost Category	Cost (1994$)		
Vehicle cost	$17,880		
Resale value	$8,046		
Annualized cost of vehicle	$3,278		
Vehicle cost per mile		$0.33	
Average fuel economy (miles per GEG)			21.80
Fuel cost/year	$900		
Maintenance per year	$1,044		
Repair per year	$130		
Annual operating cost	$2,074		
Operating cost per mile		$0.21	
Total Cost per Mile		**$0.54**	

Alternative Fuel Vehicle Assumptions:

1) Alcohol vehicle price is the same as for the comparison gasoline vehicle.
2) The EV price, including batteries, is $5,000 more than that of the comparison gasoline vehicle.
3) The propane vehicle price is $1,500 more than that of the comparison gasoline vehicle.
4) EV capital cost includes annualized costs for infrastructure installation ($1000, 30 year life) and replacement of lead acid batteries ($2,000, every 20,000 miles).
5) Alcohol and propane vehicle energy efficiencies are equivalent to the comparison gasoline vehicle.
6) EV energy efficiency is 0.3 kWh per mile.
7) Alcohol FFV maintenance costs are higher than gasoline costs due to the use of more costly oil ($1.50 per quart incremental cost).

8) EV maintenance costs are one half the cost of maintaining a conventional vehicle (California Air Resources Board, April, 1994).
9) Propane vehicle maintenance costs are equal to the cost of maintaining a conventional vehicle.
10) Alcohol, electric, and propane vehicle repair costs are equal to conventional vehicle cost (based on prices of nationally available 5-year service contracts).

Figure 8-10
Capital and Operating Costs per Mile



8.7 CONCLUSIONS

The most obvious conclusion of the cost analyses presented here is that, with current technology, prices, and taxes, alternative fuels (other than low-level ethanol blends) are more costly than gasoline. The analyses provide much more information than that, however. Each cost projection is based on several parts. It is possible, with this analysis and the analysis tools developed in this project, to estimate what will happen if any one of those parts - or several of those parts - were to change.

The most significant cost element in alcohol-fueled transportation is the cost of the fuel. Projected fuel costs for M85 and E85 are higher than gasoline, on a gasoline equivalent gallon basis, for all cases tested. If state and county fuel tax rates were to be adjusted on the basis of energy content, projected M85 and E85 costs would be comparable or less than current gasoline prices in two cases. Key cost elements are feedstock and processing costs; application of federal tax incentives; and fuel transport (shipping, hauling, and terminal) costs.

For electric vehicles, the most significant cost element is the cost of the vehicles. A variety of technologies, manufacturers, and prices are available; the rapid pace of development in this area makes a comparative cost estimation for electric vehicles extremely difficult. If electric vehicle purchase costs could be reduced, EVs could become very cost-competitive in the marketplace.

For fleet use of propane, the main cost element is the vehicle conversion cost. For non-fleet use of propane, the high price of retail propane is an additional factor.

The next chapter explores some possible means, given the costs projected in this chapter, of encouraging the use of alternative transportation fuels.